National Aeronautics and
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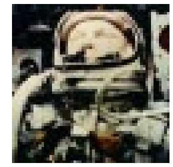
Glenn Research Center
Cleveland, Ohio

John Glenn
Biomedical Engineering Consortium
Helping Astronauts, Healing People on Earth



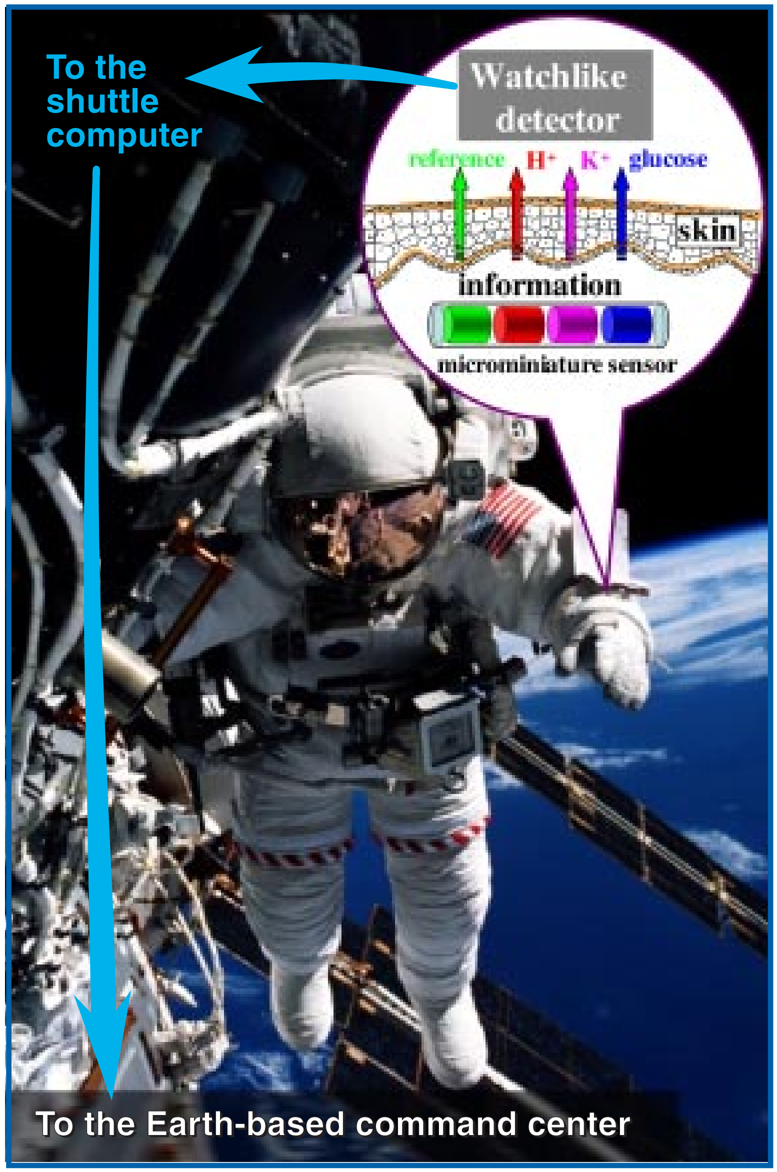
Microminiature Device Monitors Vital Electrolytes and Metabolites

A microminiature sensor that can be easily and painlessly placed just under the skin is being developed to monitor vital fluids in the body. This device would be extremely useful on Earth for continuous monitoring of many clinical conditions.

Astronauts face the possibility of becoming ill while in space. When they do, doctors on Earth have to make a diagnosis from a distance of several thousand miles. The better information the doctors have, the better the chances of making a correct judgement and suggesting effective treatment.

Vital fluids are reliable indicators of processes and reactions in the human body, which is why a blood test can tell doctors so much about a patient's condition. Ions and potassium, for example, play a crucial role in maintaining proper functioning of cells and tissues. Metabolites such as glucose control the energy available to the entire human body in normal and stress situations. Monitoring and chemical analysis of body fluids would be useful for understanding the response of living systems to different conditions in space, during launch, flight, and reentry. However, monitoring of astronauts during space flight requires regular collection and in vitro analyses of blood samples drawn from the astronauts. It is highly desirable to replace this multistep and invasive procedure with continuous in vivo diagnostic monitoring.

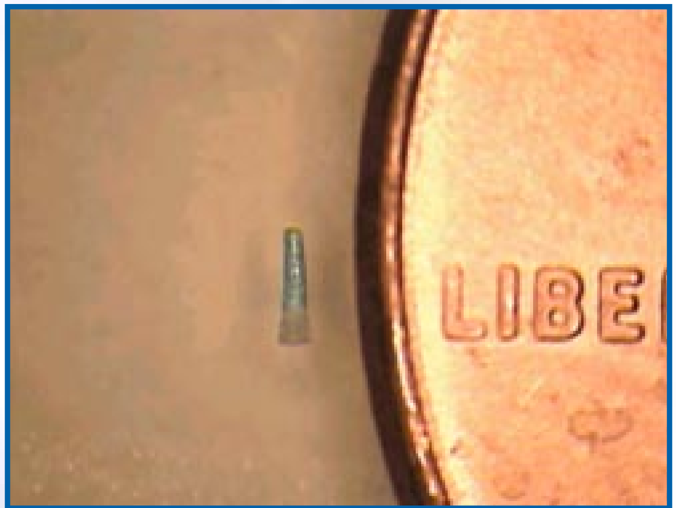
To date, no such continuous, minimally invasive monitor for ions and metabolites is available, even in terrestrial settings. Most technologies are at least several years away from the first human applications. A new approach has been conceived and tested, however, that could realize such a goal for the first time. The approach is painless, does not require the collection of blood samples, and needs negligible energy, water, or labor. So far, it is performing beyond expectation in preliminary laboratory tests.



Within the John Glenn Biomedical Engineering Consortium (GBEC), principal investigator Miklos Gratzl and co-investigator Koji Tohda, both of Case Western Reserve University, Department of Biomedical Engineering, are developing a fully functional, microminiature sensor that can be placed just under the skin. The sensor is entirely passive, without the need for a battery. The research approach is a synthesis of several novel concepts to achieve painless and very accurate in vivo monitoring of vital levels of electrolytes (such as potassium) and metabolites (such as glucose) in the interstitial fluid between cells and tissues in the body. Continuous monitoring of the interstitial fluid is a simpler and better alternative to taking repeated blood samples.

The multifunctional sensor will be operational for several days, after which its replacement will be safe enough for the astronauts to perform themselves, easily and painlessly. The design of the sensor tip makes insertion virtually free of cell or vessel damage, in contrast to the tip of an ordinary hypodermic needle. The sensor is so tiny (1 to 2 millimeters long and 100 to 200 micrometers wide) that it causes no discomfort to the person wearing it. It can be monitored by eyesight and by electronic telemetry using a watchlike device worn by the person for data processing in an Earth-based command center. Since no wires are required to cross the skin, there is no chance of track infection. And in vitro calibration is not necessary, due to a self-calibrating feature incorporated in the sensor.

Clinical capabilities during space flight will be significantly enhanced by the continuous approach to monitoring body fluid chemistry. Management of medical emergencies in space may be made easier with a continuous monitor already in place and vital biochemical data readily available. It is anticipated that the targeted medical conditions can be diagnosed earlier and more fully with the sensor and monitoring system.



The tiny sensor, much smaller than a penny, changes optical characteristics depending on the amount of glucose that is present.

Benefits on Earth

Once such a tiny, multivariable physiological monitor is functional for astronauts, it would take little additional effort to make it suitable for patient monitoring on Earth for many kinds of clinical conditions. Diabetics in particular would greatly benefit from this technology, which would take the place of a conventional macro- or mini-sensor. In addition to freeing patients from having to test sugar levels by taking blood samples several times a day, such a microminiature device could conceivably be used for automatic control of an insulin pump.

This entirely new approach to assessing of vital fluids may lead to a robust and safe sensing technology for in vivo monitoring of ions and metabolites for everyone.

For more information about the John Glenn Biomedical Engineering Consortium or consortium projects, please contact
Marsha M. Nall
NASA Glenn Research Center
21000 Brookpark Road MS 77–7, Cleveland, Ohio 44135
grcbio@grc.nasa.gov

http://microgravity.grc.nasa.gov/grcbio

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